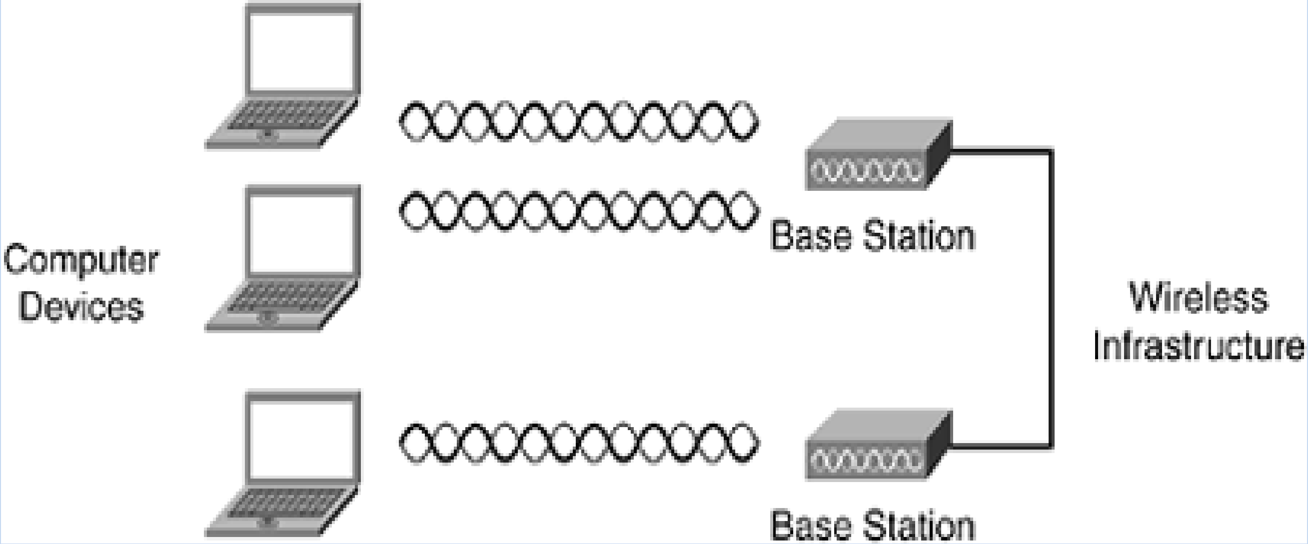
Wireless Networks

Wireless Network System Components

A wireless network consists of several components that support communications using radio or light waves propagating through an air medium.



Wireless Network System Components

Users

A user can be anything that directly utilizes the wireless network.

- One of the most common types of user is a person.
- In some cases, the user might not be human. A robot, for example, might receive instructions over a wireless network from a central computer that controls a manufacturing process.
- Because the wireless network exists to serve the user, the user is the component that receives the benefits of a wireless network. <u>As a result, users are an important part of the wireless network.</u>

Wireless Network System Components

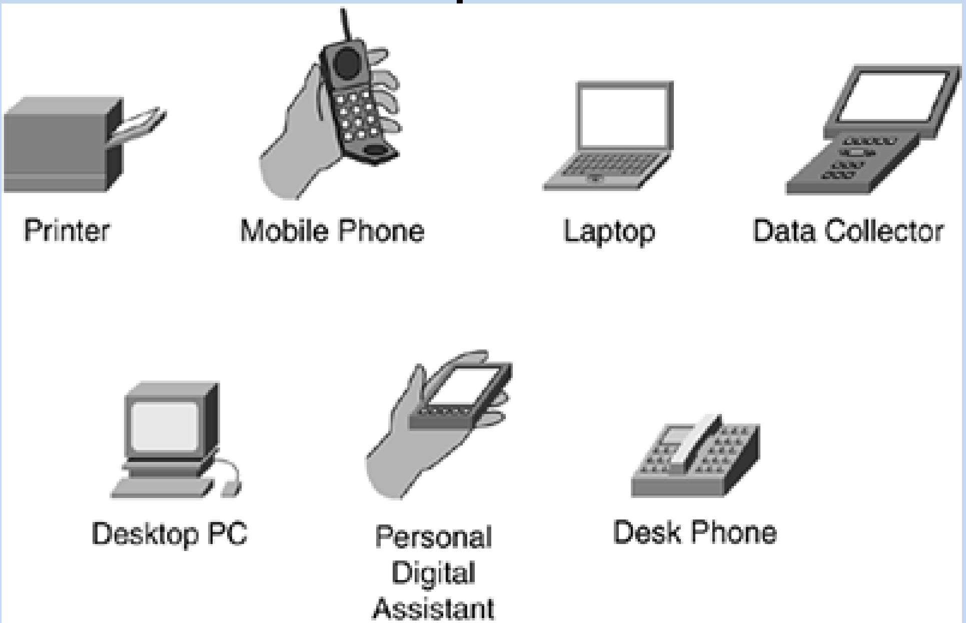
Question:

Why the User is referred to as End User?

Wireless Network System Components

Computer Devices

Many types of computer devices, sometimes referred to as clients, operate on a wireless network. Some computer devices might be specifically designed for users, whereas some computer devices are end systems.



Wireless Network System Components

NICs

The Network Interface Card provides the interface between the computer device and the wireless network infrastructure. The NIC fits inside the computer device, but external network adaptors are available that plug in and remain outside the computer device.

Wireless network standards define how a wireless NIC operates. For example, a wireless LAN NIC might implement the IEEE 802.11b standard. In this case, the wireless NIC will only be able to interface with a wireless network infrastructure that complies with the 802.11b standard.

Wireless Network System Components

Air medium

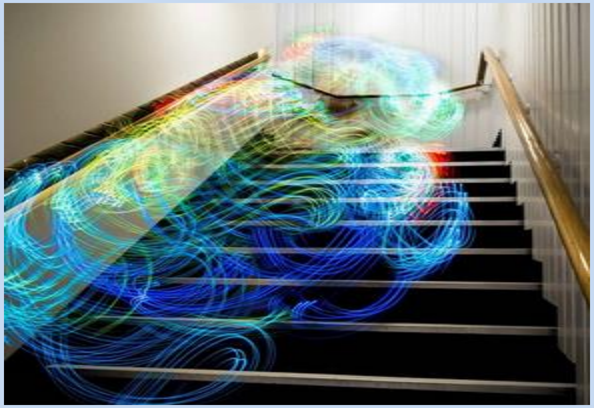
Air also provides a medium for the propagation of wireless communications signals, which is the heart of wireless networking. Air is the conduit by which information flows between computer devices and the wireless infrastructure.

Think of communication through a wireless network as similar to talking to someone. As you move farther apart, it's more difficult to hear each other, especially when a loud noise is present.

Wireless Network System Components

Wireless information signals also travel through the air, but they have special properties that enable propagation over relatively long distances. Wireless information signals cannot be heard by humans, so it's possible to amplify the signals to a higher level without disturbing human ears. The quality of transmission, however, depends on obstructions in the air that either lessen or scatter the strength and range of the signals.

The infrastructure of a wireless network interconnects wireless users and end systems. The infrastructure might consist of base stations.



Wireless Network Infrastructures

Base Station

The base station is a common infrastructure component that interfaces the wireless communications signals traveling through the air medium to a wired network—often referred to as a distribution system.

A base station often contains a wireless NIC.

An access point, for instance, represents a generic base station for a wireless LAN. A collection of access points within a wireless LAN, for example, supports roaming throughout a facility.

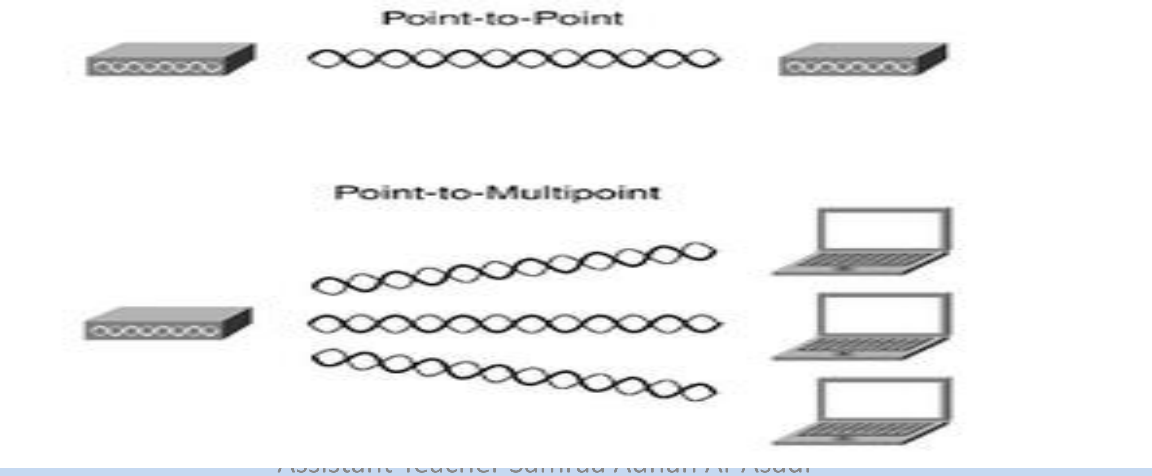
The NIC within a user's computer device connects with the nearest access point.

As the user moves to a part of the facility that's closer to another access point, the NIC automatically reconnects with the closest access point to maintain reliable communications.

Residential gateways and routers are more advanced forms of base stations that enable additional network functions. The gateway might have functions, such as access control and application connectivity, that better serve distributed, public networks.

On the other hand, a router would enable operation of multiple computers on a single broadband connection.

a base station might support point-to-point or point-to-multipoint communications. Point-to-point systems enable communications signals to flow from one particular base station or computer device directly to another one.



Access Controllers

Hardware that resides on the wired portion of the network between the access points and the protected side of the network.

Access controllers provide centralized intelligence behind the access points to regulate traffic between the open wireless network and important resources.

Access controllers generally employ the following features: Authentication, Encryption, Subnet Roaming, Bandwidth Management

Application Connectivity Software

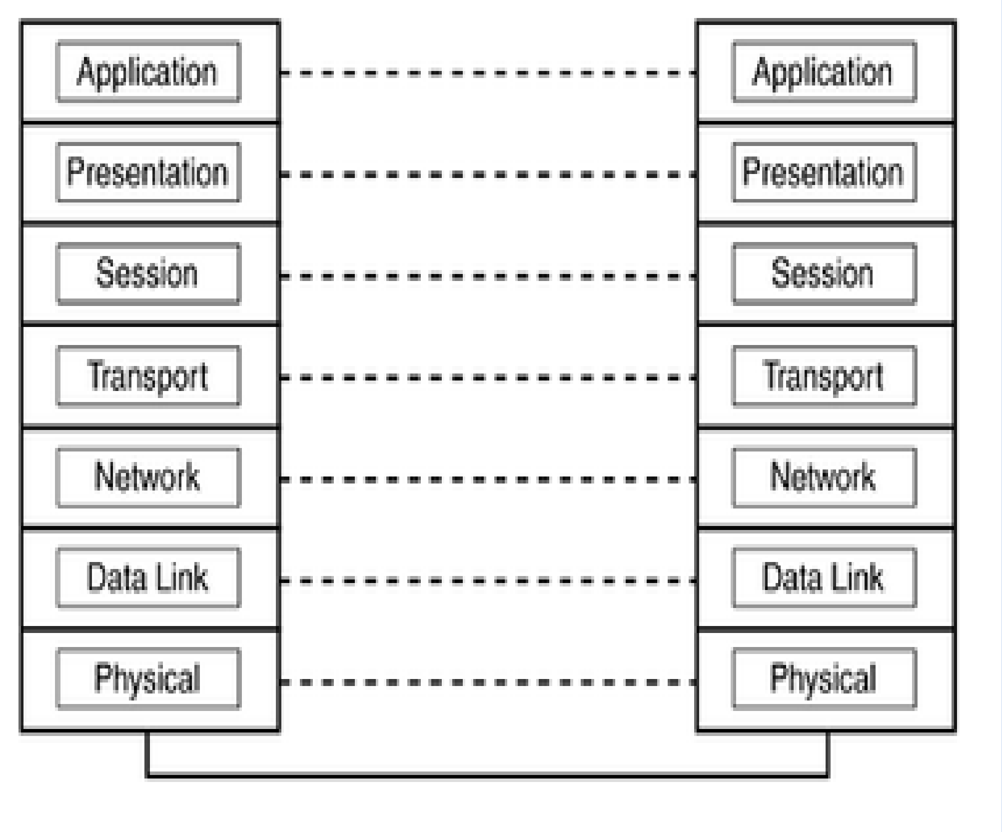
Web surfing and e-mail generally perform well over wireless networks. All it takes is a browser and e-mail software on the client device. Users might lose a wireless connection from time to time, but the protocols in use for these relatively simple applications are resilient under most conditions.

Distribution System

A wireless network is seldom entirely free of wires. The distribution system, which often includes wiring, is generally necessary to tie together the access points, access controllers, and servers. In most cases, the common Ethernet comprises the distribution system.

Network Architecture

- One popular standard for illustrating the architecture is the seven-layer Open System Interconnect (OSI) Reference Model.
- The OSI Reference Model is also a handy model for representing the various standards and interoperability of a wireless network.



- The physical layer of the OSI model defines connector and interface specifications, as well as the medium (cable) requirements. Electrical, mechanical, functional, and procedural specifications are provided for sending a bit stream on a computer network.
- The Data Link Layer of the OSI model provides the following functions:

- Allows a device to access the network to send and receive messages
- Offers a physical address so a device's data can be sent on the network
- Works with a device's networking software when sending and receiving messages
- Provides error-detection capability
- The Network Layer of the OSI model, provides an end-to-end logical addressing system. Here are the basic functionalities of the network layer:
- Switching and routing technologies work here

Creates logical paths between two hosts across the world wide web called as virtual circuits

Routes the data packet to destination

Routing and forwarding of the data packets.

- The transport layer of the OSI model, offers end-to-end communication between end devices through a network. Depending on the application, the transport layer either offers reliable, connection-oriented or connectionless, best-effort communications.
- The session layer, provides various services, including tracking the number of bytes that each end of the session has acknowledged receiving from the other end of the session. This session layer allows applications functioning on devices to establish, manage, and terminate a dialog through a network.
- The presentation layer, is responsible for how an application formats the data to be sent out onto the network. The presentation layer basically allows an application to read (or understand) the message.
- The application layer, provides an interface for the end user operating a device connected to a network. This layer is what the user sees, in terms of loading an application (such as Web browser or e-mail); that is, this application layer is the data the user views while using these applications.

Information Signals

Data is a type of information that the network stores in a computer or retrieves from it. As a result, wireless networks transfer data from one computer to another.

Communications systems ”such as a wireless network” symbolize data using codes that electrical, radio, and light signals efficiently represent. The signals carry the information through the system from one point to another.

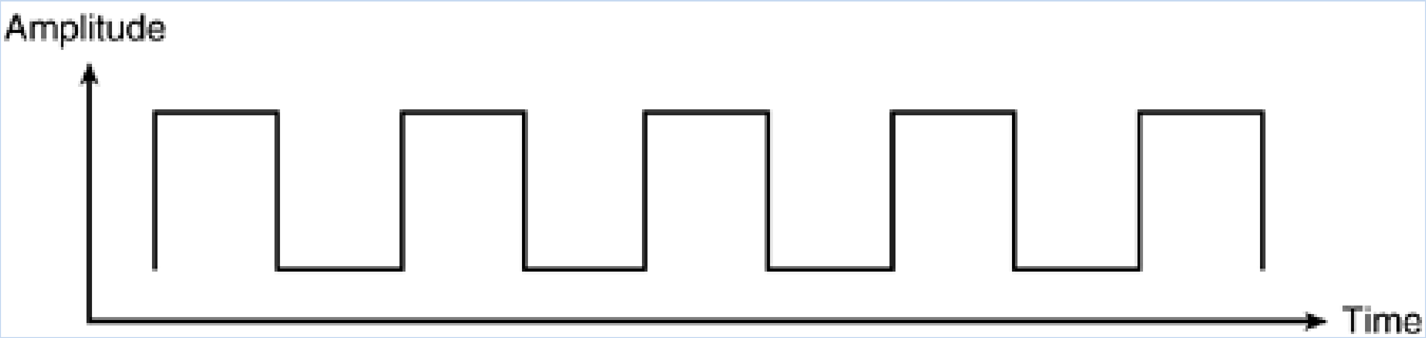
The signals are either **digital** or **analog**, depending on their location within the system.

Information Signals

Digital Signals

Digital signals are found inside computers, they are vary in amplitude steps as time advances.

Digital signals are usually binary (two-state); therefore, it is common to refer to the signal as a string of binary digits (bits) or binary data. Digital circuitry inside the computer easily stores and processes these digital signals in binary form.



Information Signals

Digital Signals

One of the **advantages** of digital signals is **easy signal regeneration**. As a signal propagates through the air medium, it might encounter noise or interference that changes the appearance of the signal's waveform. To clean up and regenerate the signal, digital circuitry can detect if a digital pulse is present at a certain period of time and create a new pulse that is exactly equal to the one originally sent. As a result, a digital signal can be sent over vast distances through periodic repeaters while preserving the integrity of the information.

Information Signals

Digital Signals – Characteristics

Data rate it corresponds to the speed that a digital signal transfers data across a wireless network, so, the data rate of a digital signal gives some insight on how long it will take to send data from one point to another, as well as identify the amount of bandwidth that the medium must supply to effectively support the signal.

The data rate of a signal is equal to the total number of bits transmitted in relation to the time it takes to send them.

The common unit of measure for bit rate is bits per second (bps). As an example, consider a signal that moves 1,000,000 bits in 1 second. The data rate is 1,000,000/1 = 1,000,000 bps (or 1 Mbps).

Information Signals

Digital Signals – Characteristics

Throughput is similar to data rate; however, throughput calculations generally exclude the bits that correspond to the overhead that communications protocols include.

Throughput is usually includes only the actual information being sent across the network.

The data rate of a wireless LAN, for example, might be 11 Mbps, but the throughput might be only 5 Mbps.

After removing the overhead (frame headers, error checking fields, acknowledgement frames, and retransmissions because of errors) the resulting information transfer is considerably lower. As the number of users increases, contention for the shared medium increases, which drives throughput even lower because computer devices (wireless NICs) must wait longer before sending data. This delay, which is a form of overhead, can significantly lower the throughput.

Information Signals

Digital Signals – Characteristics

Throughput

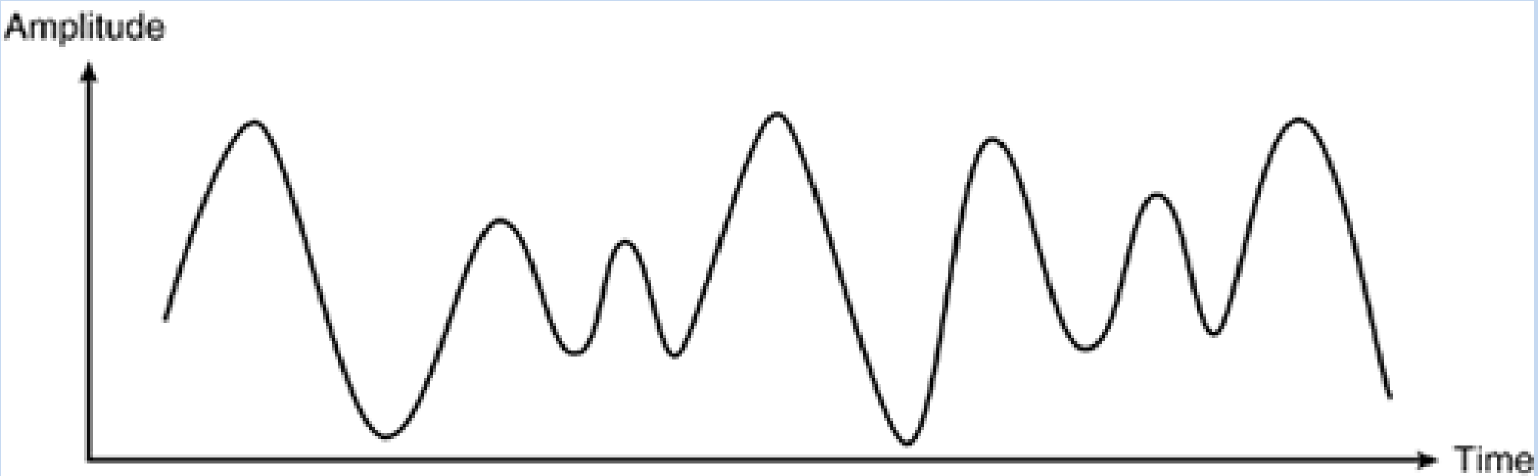
Throughput gives a more accurate way of representing the true performance and efficiency of a network. This makes throughput important when comparing wireless networks because it's directly related to performance.

The higher the throughput, the higher the performance.

Information Signals

Analog Signals

Wireless network converts the binary digital signals into analog before transmitting the signal through the air medium. The amplitude of the analog signal varies continuously as time progresses. As examples of analog signals are light and the human voice.



Information Signals

Analog Signals

An analog signal has amplitude, in units of voltage or power, and a frequency (a specific number of cycles per second that is referred to as Hertz).

Wireless networks generally use analog signals at 2.4 GHz, which is in a band of frequencies referred to as radio waves.

Flow of Information Through a Wireless Network

Interfacing with the Air Medium

1. After the user instructs the computer device to send information over the wireless network, the computer device negotiates a connection to the remote computer.

2. After establishing a connection, the computer device delivers the data in digital form to the wireless NIC.

3. The sending wireless NIC converts the data to an analog radio frequency or light wave signal before transmission through the antenna. This conversion requires **modulation**, which involves conversion of the signal from digital to analog.

4. After modulation, the signal propagates through the air medium to the receiving wireless NIC, which **demodulates** and processes the received signal

Modulation

- Modulation: Converting Digital or Analog information into waveform suitable for transmission over a giving medium.
- It is the process of varying some parameter of a wave pattern to use that variance to convey some kind of information.
- Developing efficient ways of massaging a signal so that it can be transmitted and properly interpreted from one place to another over a given medium.
- A device that performs modulation is known as a *modulator*.
- A device that performs the reverse operation of modulation is known as a *demodulator*.

Modulation Techniques

- **Spread-Spectrum Modulation Techniques**

A modulation technique that spreads a signal’s power over a wide band of frequencies so the transmitted signal occupies more bandwidth than the actual information being modulated.

The main reason for this technique is that the signal becomes much less susceptible to electrical noise and interferes less with other radio-based systems

In spread-spectrum techniques, the carrier signals occur over the full bandwidth or spectrum of the transmitting frequency.

Modulation Techniques

- **Digital Modulation Techniques**

Digital modulation techniques are employed when there is a need to convert digital signals to analog signals.

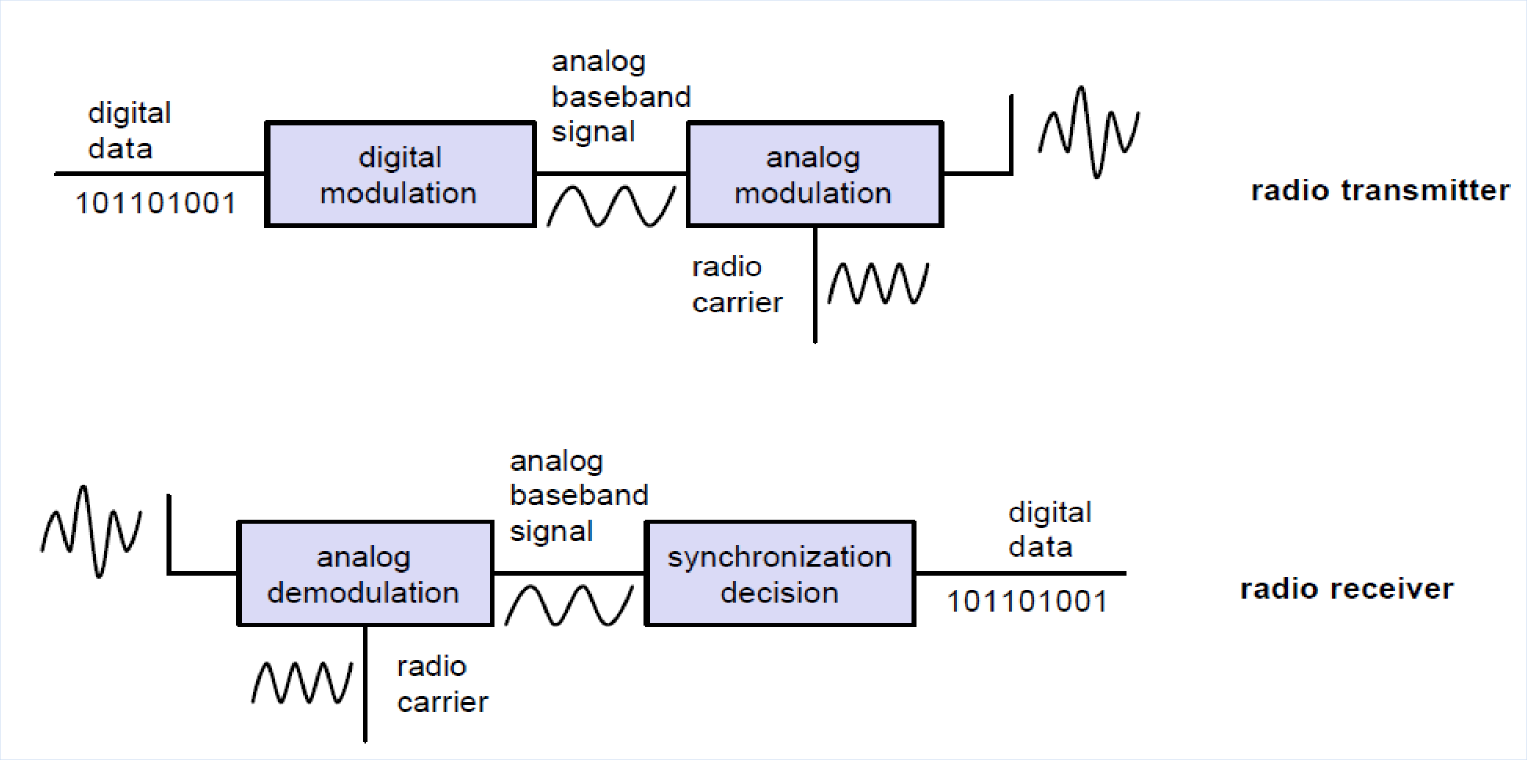
The converse of digital modulation would be demodulation the conversion of analog signals to digital form.

In the digital modulation world, there are currently three methods used to perform this conversion, and they all depend on varying some attributes of a sine wave representing the signal.

These attributes are frequency (FSK: Frequency-shift keying),
Amplitude (ASK: Amplitude-shift keying),
and phase (PSK: Phase-shift keying).

Modulation Techniques

- **Digital Modulation Techniques**



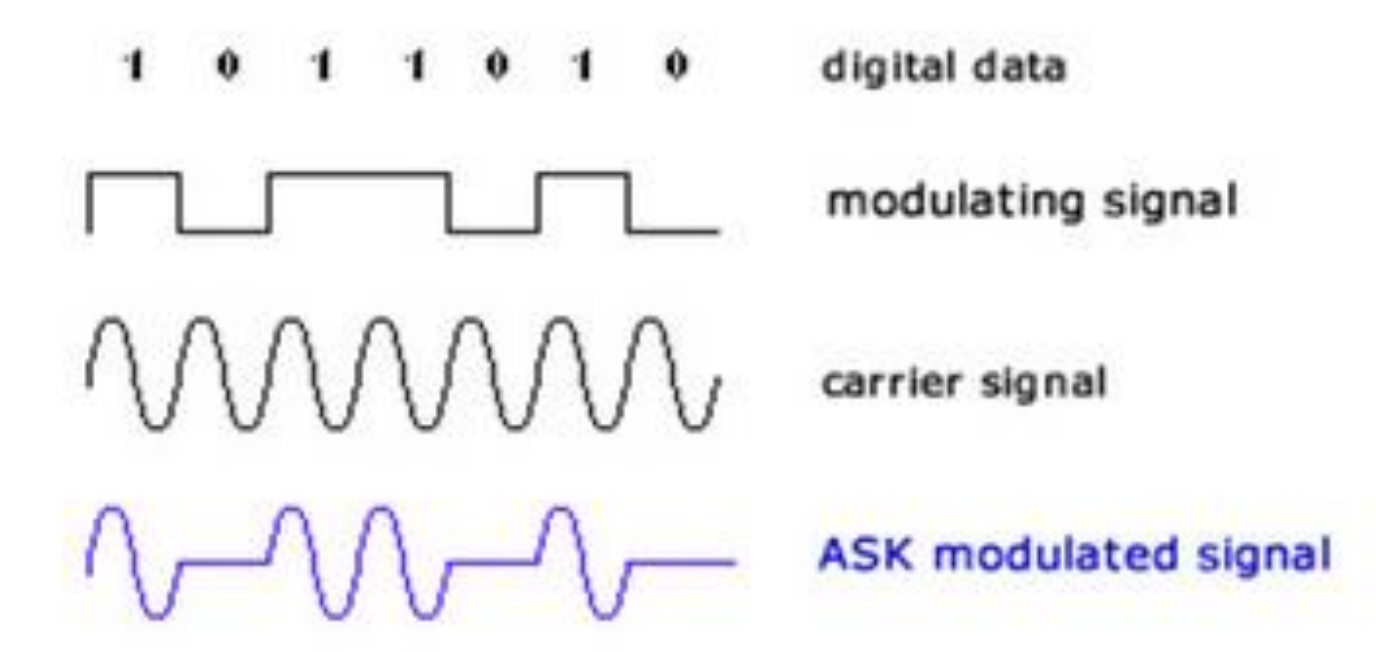
Modulation Techniques

- **Digital Modulation (ASK: Amplitude -shift keying)**

  - Change Amplitude with each symbol: , amplitude has 2 levels (for bit 1 and for bit 0) so the strength of the carrier signal is varied to represent binary 1 and 0.
  - Frequency and phase are kept constant
  - low bandwidth requirements
  - very susceptible to interference

Modulation Techniques

- **Digital Modulation (ASK: Amplitude -shift keying)**



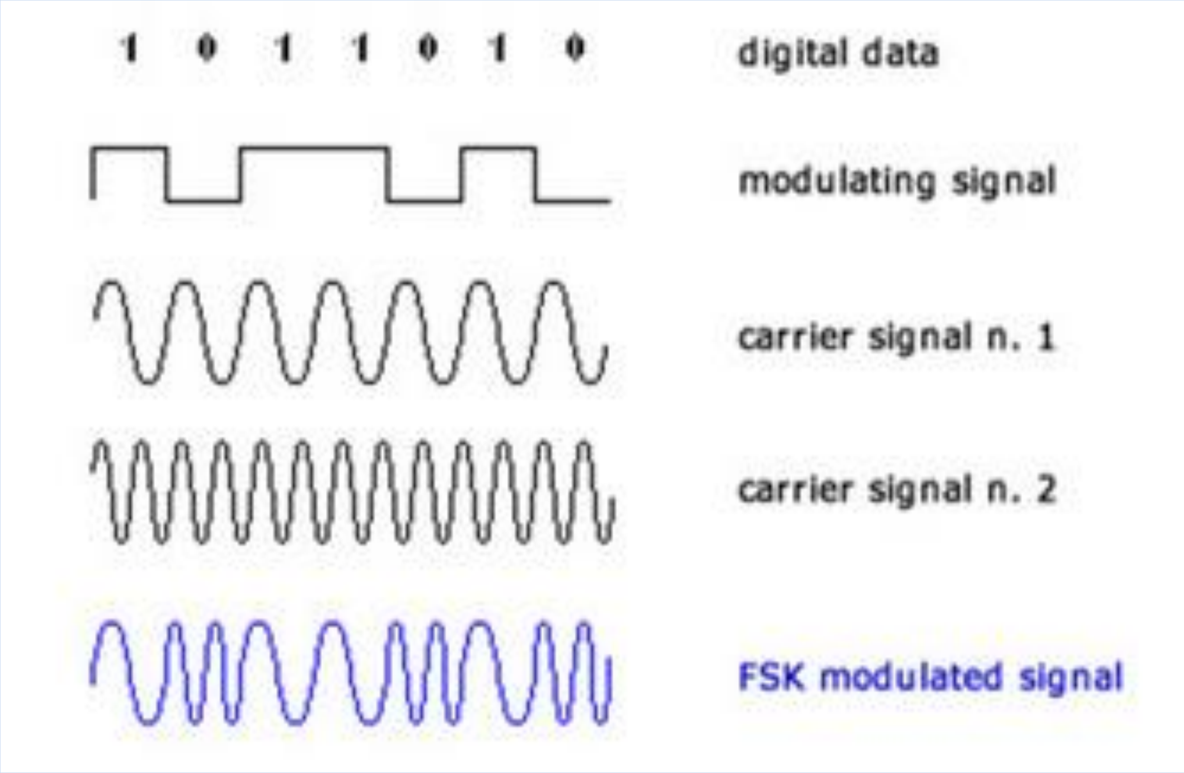
Modulation Techniques

- **Digital Modulation (FSK: Frequency-shift keying)**

  - Change the frequency with each symbol.
  - Peak amplitude and phase remain constant.
  - Needs larger bandwidth.
  - Avoid noise interference by looking at frequencies (change of a signal) and ignoring amplitudes.

Modulation Techniques

- **Digital Modulation (FSK: Frequency-shift keying)**



Modulation Techniques

- **Digital Modulation (PSK: Phase-shift keying)**

  - Phase of the carrier is varied to represent digital data (binary 0 or 1)

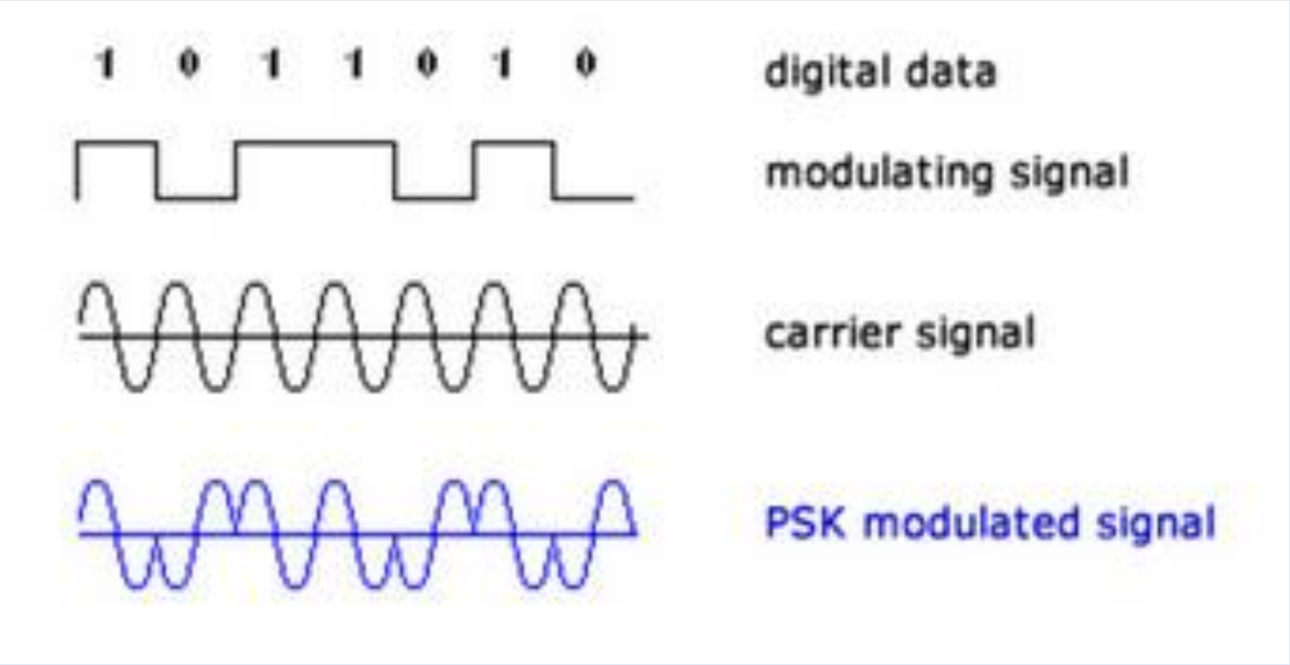
  - Amplitude and frequency remains constant.

  - If phase 0 deg. to represent 1, 180 deg. to represent 0. (2-PSK)

  - PSK is not susceptible to noise degradation that affects ASK. It is robust against interference.

Modulation Techniques

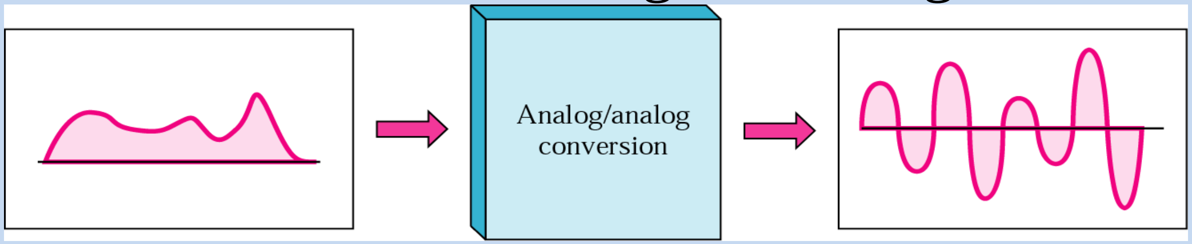
- **Digital Modulation (PSK: Phase-shift keying)**



Modulation Techniques

- **Analog Modulation Techniques**

If the signal information is to be used and processed only within the computer system, it can remain and die in its digital form. But when it comes to communicating the digital information wirelessly to other entities, the information has to be repackaged into a form that can be transmitted using the analog wireless medium.



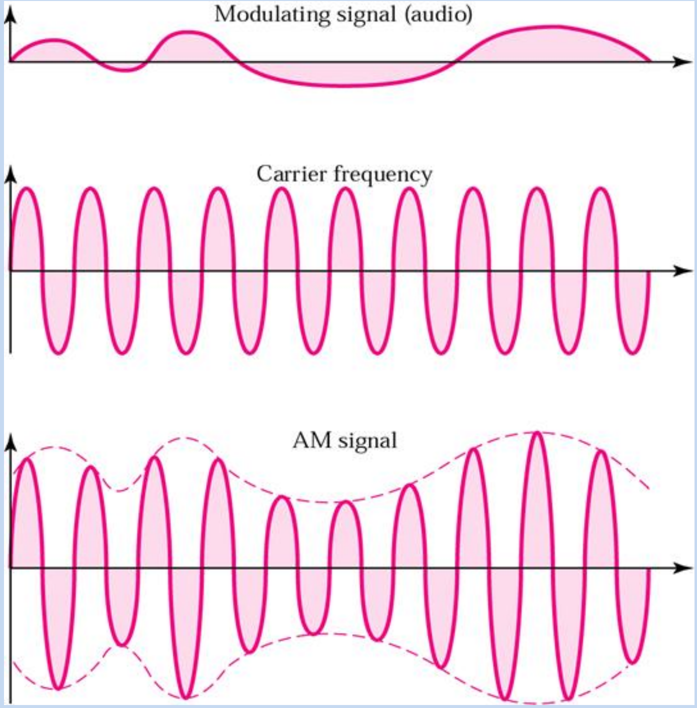
(i) Amplitude Modulation A.M.

(ii) Frequency Modulation F.M.

(iii) Phase Modulation P.M.

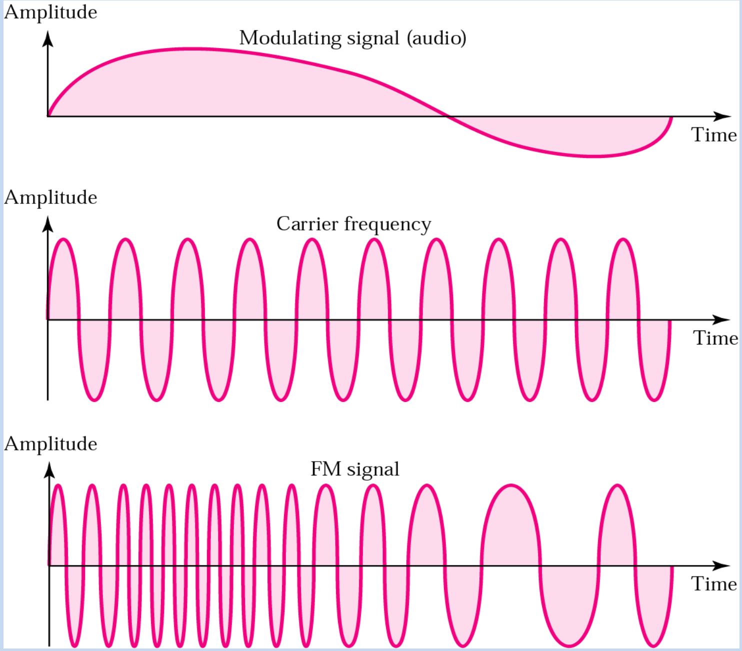
Modulation Techniques

- **Analog Modulation- AM**



Modulation Techniques

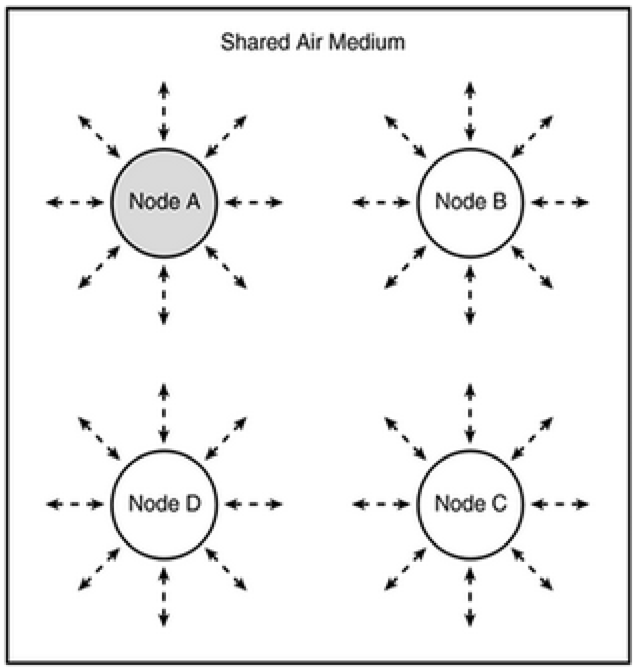
- **Analog Modulation- FM**



Medium Access

- An important aspect of the transmission of data over a wireless network includes medium access, a data link layer function that comprises protocols that all wireless NICs must follow.

- If Node A has data to send, Node A first checks, senses, if any other nodes are transmitting data.
- If the medium is clear no transmission is heard.
- Node A will transmit one frame of data.
- If Node A senses transmissions from another node, Node A holds off transmitting and waits a period of time before sensing the channel again.
- The sensing operation continues until the node sends the data frame.



- Collisions can occur with Carrier Sense Multiple Access (CSMA) even though the transmitting node senses the channel first before sending data. The reason for this is the non-zero propagation delay between the nodes.
- The transmission coming from a particular node does not block all nodes from transmitting until the signal reaches all other nodes.

Reference

Wireless Networks first-step